RESTORATION

CRADLE SONG

Early geotechnical involvement was key to the success of a complex scheme to protect an historic canal lock in north-east England.

Keadby Lock has experienced a variety of movements since it was built in 1770. Situated at the junction of the Stainforth and Keadby Canal and the River Trent near Scunthorpe in north Lincolnshire, the lock was the gateway to the North Sea for much of the manufacturing goods from the nearby industrial city of Sheffield. It is the oldest in the UK and its status as Scheduled Ancient Monument puts it in the same league as Stonehenge.

The lock is 23m long, 7m wide and 7m deep and has three chambers. Its walls, built from lime rubble with a stone facing, are 1.8m thick and founded on timber beams stretching across the lock between them, just below the base.

From the start, heave of the floor and settlement of the walls caused hogging of the timber beams in the centre of the lock base. While vertical wall settlement dominated in the dock's early life, this movement has now been overtaken by additional inward rotation of the walls.

British Waterways began monitoring movements in 1997, as part of its asset management policy. Ongoing inward rotation of the lock walls was identified, between 2mm and 4mm each year at coping level.

The lock is built in a significant depth of soft to firm alluvial clays. Ground conditions are very poor over the top 13m, comprising a soft to firm slightly sandy silt down to 8m and then a soft to firm slightly organic sandy clay down to 13m. Weak Mercia Mudstone is beneath.

A feasibility study and site investigation carried out by consultant Mott MacDonald and completed in January 2003 concluded that a support cradle built around the lock was needed to resist the active ground pressures acting on the walls.

Contiguous bored pile walls down each side of the lock were to form the vertical elements of the cradle, with jet grouting beneath the lock and its walls to beyond the new pile walls as the horizontal element. Pile capping beams would be cast with reinforced concrete beams between the original timbers running across and beneath the dock floor. Finally, the lock walls would be stabilised by installing steel ties and grouting up voids.

It was clear to British Waterways and its omnibus framework contractor GallifordTry that remedial works were going to present a significant geotechnical challenge. So it decided to approach three major geotechnical contractors several months before site work was due to start.

This allowed each firm time to produce budget costs for the feasibility scheme and at the same time encouraged them to develop alternatives and improvements. Work was let on an NEC Option D target cost contract with shared "pain and gain".

Cementation Foundations Skanska was chosen as the preferred contractor to develop the detailed scheme in July 2003. This allowed five months to optimise the design, before site work began in November.

"The overall philosophy of our scheme was to incrementally strengthen the old lock walls using small plant, and then to form the support cradle around the whole lock using larger equipment," Cementation ground engineering technical manager Jim Martin explains.

Four aspects of its proposal helped Cementation win the contract, he says.

"We decided to use CFA piles instead of rotary bored piles for the wall; to use a precast rather than cast insitu pile capping beam; to use minipiles in the lock base rather than jet grouting; and to fully integrate piling and ground engineering techniques."

Design of the complex scheme would have been difficult using conventional geotechnical design techniques, Martin continues.

Cementation worked with Geotechnical Consulting Group director Hugh St John to "optimise the remedial scheme, with detailed analysis of the interaction between the ground, the old structure and the new work".

GCG's Nesha Kovacevic modelled the original construction concept and subsequent remedial works in a number of stages using ICFEP (Imperial College finite element program).

"To transfer the soil pressures from the old to the new structure it had to be assumed that the timber beams in the base of the lock had rotted away and stopped providing any support after the remedial works had been completed," Martin explains.

This generated the worst credible forces in the new works, which Cementation was then able to use to design the individual geotechnical elements. York-based consultant Dossor Group designed the precast and insitu concrete beams.

"There were several intensive meetings between all the parties involved, where potential design and construction risks were fully discussed.

"These meetings were often difficult, but in the end they produced the optimum cost effective solution for the client," Martin says.

The overall target cost for the scheme was agreed in October 2003 at £1.15M, with Cementation's contract worth £600,000.

"Various items were also added to the risk register, including £20,000 for coring barrels if the CFA piles encountered obstructions," Martin adds.

The 22-week contract began on site at the beginning of November. The deadline for completion could not be moved – British Waterways has to reopen the lock due to canal traffic by Easter.

After establishing site offices, GallifordTry sealed off the lock and